EFFECT OF AUTOMATED COOLANT SUPPLY SYSTEM ON CNC TURNING PERFORMANCE

Submitted in accordance with the requirement of University Technical Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons)

by

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I hereby, declared this report entitled “Effect of Automated Coolant Supply System on Turning Performance” is the result of my own research except as cited in references.

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Author’s Name : VANNESSA LIPANG HENRY

Date : 20 JULY 2020

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The members of the supervisory committee are as follow:

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ABSTRAK

Dalam industri pembuatan moden, teknik mesin kering dan penyejukan nasah adalah dua (2) jenis teknik penyejukan yang biasa digunakan. Walau bagaimanapun, kedua-dua teknik penyejukan ini mempunyai kelemahan yang mengakibatkan kesan buruk pada benda kerja, perkakas, kesihatan, ekonomi dan persekitaran. Lebih-lebih lagi, dengan menggunakan teknik penyejukan basah, kos pelupusan cecair pemotongan mampu mencapai dua hingga empat kali lebih tinggi daripada harga pembeliannya. Ini kerana cecair pemotong tidak terbiodegradasi dan memerlukan pemprosesan yang mahal sebelum dibuang. Oleh itu, idea menggunakan teknik Pelumasan Kuantiti Minimum dan PLC diilhamkan untuk mengatur kuantiti penyejuk dan masa penyediaan penyejuk. Justeru itu, tujuan projek ini adalah untul menganalisis prestasi bekalan penyejuk automatic yang dicadangkan dari segi perincian masa selang dan pada masa yang sama untuk menentukan kekasaran permukaan terbaik berbanding masa selang. Untuk projek ini, waktunya ditetapkan untuk menutup injap dan injap mesti dibuka dan terus membekalkan penyejuk sehingga ditutup kerana masa mengendap setelah sejumlah waktu. Analisi yang digunakan dalam eksperimen terdiri daripada pengujian prestasi penyejuk yang tidak dimuat dan juga penyejuk berdasarkan masa, di mana hasilnya merujuk kepada kuantiti permukaan benda kerja. Prestasi setiap bekalan penyejuk iaitu 1 saat hingga 60 saat dengan selang waktu 5 saat dinilai dengan mendapatkan kekasaran permukaan dari setiap bahagian berpusing. Kekasaran permukaan diperiksa dan ditentukan menggunakan penguji kekasaran Mitutoyo di Makmal Metrologi. Hasilnya menunjukkan bahawa sistem penyediaan penyejuk automatic yang dicadangkan adalah teknik yang menjanjikan untuk digunakan sebagai kekasaran permukaan terbaik dari bahan kerja yang diperoleh pada waktu selang 15 saat bekalan penyejuk. Hasil ini

membuktikan bahawa bekalan penyejuk tidak perlu dibekalkan secara berterusan, kerana kekasaran yarng baik masih dapat dicapai.

ABSTRACT

In the modern manufacturing industry, dry machining and wet cooling techniques are two (2) types of cooling techniques that are commonly used. Both cooling techniques however, have their drawbacks which result in adverse effects on the workpiece, tooling, health, economy and environment. Moreover, with the used of wet cooling techniques, the cost for disposal of cutting fluids is capable of reaching two to four times higher than their purchase price. This is because cutting fluids are non-biodegradable and requires expensive processing before being disposed. Thus, the idea of using Minimal Quantity Lubrication technique and PLC is inspired to regulate the quantity of coolants and the timing of the supply of coolants. Therefore, the aim of this project is to analyse the performance of the proposed automated coolant supply in term of details interval time and at the same time to determine the best surface roughness vs the interval time. For this project the timing is set to close the valve and the valve must open and continue to supply coolants until closing due to time settling after a certain amount of time. The analysis applied in the experiment consists of performance testing of unloaded coolants as well as time-based coolant, where the result refers to surface quality of the workpiece. The performance of each coolant supply which is 1 second to 60 seconds with time interval of 5 seconds is evaluated by obtaining the roughness of the surface from each turning part. The surface roughness is examined and determined using the Mitutoyo roughness tester in Metrology Lab. The result shows that the proposed automated coolant supply system is a promising technique to be used as the best surface roughness of the workpiece was obtained during the interval time of 15 seconds of coolant supply. This result proves that coolant supply needs not to be supplied continuously, as a good roughness is still achievable.

DEDICATION

This study is wholeheartedly dedicated to my beloved parents, who have been my source of inspiration and gave me strength when I thought of giving up, who continually provide their moral, spiritual, emotional and financial support.

Also to my Lecturer and friends who shared their words of advice and encouragement to finish this study.

And lastly, I dedicated this research to the Almighty God for His guidance, strength, power of mind, protection and skills. All of these, I offer to you.

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LIST OF ABBREVIATION

CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
CNC	-	Computer Numerical Control
LED	-	Light-emitting Diode
MQL	-	Minimal Quality Lubrication
NC	-	Numerical Control
PLC	-	Programmable Logic Controller

LIST OF SYMBOLS

°C	-	Degree Celsius
%	-	Percentage
min	-	Minute
ml	-	Millilitre
s	-	Second
µm	-	Micro Meter
°	-	Degree
Ra	-	Surface Roughness
V	-	Voltage
AC	-	Alternative Current
DC	-	Direct Current

CHAPTER 1

INTRODUCTION

The overview of this chapter describes the Computer Numerical Control (CNC) machine, the cleaner application software and a technique to be used in the coolants system. Next the replacement of the conventional method with PLC will also be discussed. Together with the above items, the problem statement, objectives and scopes are discussed.

1.1 Background

Yadav (2012) mentioned that Computer Numerical Controlled (CNC) machines are increasingly being used in all production procedures. It functions include as a program storage, tool offset and tool compensation, program editing capacity and varying degree of computation. Besides, it has the capacity to send and obtain information from a multitude of sources including distant places that can be readily performed on computer. Computer Numerical Controlled (CNC) machine development is a huge contribution to the manufacturing fields (Ansar et al., 2016). The programmable language controlled by the new CNC machine had been capable of performing a wider range of function more accurately. The machine efficiency enabled elevated automated control which could enhance the product productivity. In metal cutting machine (CNC machine) for instance, there are a few technologies used in the milling, lathe and turning machine. Ansar et al. (2016) reiterated that in order to improve the machine flexibility in the handling of a range of parts and complete them in a single set up on the same machine. CNC idea was used to create a CNC machining centre for machining prismatic parts combining processes such as milling, drilling, boring and tapping. The method with high machining velocity, low feed rate and low cutting depth can therefore produce heat in profusion and boost the cutting temperature in machining.

As studied by Soković and Krsto, (2001) with the aim of improving the characteristics of the tribology processes that are always present on the contact surfaces between the tool and the workpiece, cutting fluid was introduced into the cutting process. The use of cutting liquids increases tool life which adds to a more economical cutting speed and improves the effectiveness of the manufacturing systems in general. As mentioned by Yang and Tharng, (1998) tool life is a significant index for assessing cutting efficiency in a turning process. Furthermore, the aim of turning operation is to generate the machined workpiece low surface roughness. To assess cutting efficiency, surface roughness is another significant index. In fact, tool life and surface roughness were strongly associated with cutting parameters such as cutting speed, feed rate and cutting depth. Proper choice of cutting parameters can ensure longer life of tool and better roughness of the surface.

The increase in heat due to friction and energy loss may result in the cutter being unsharpened, affecting high power consumption and poor surface finishing. The poor coolant causes the low thermal conductivity in the surrounding air. According to Dhar et al. (2006), temperature increases induce rapid tool wear and deteriorate surface quality. Besides, Mia and Dhar (2015) then endorsed reducing tool wear, extended tool life, enhanced surface finish and reduced cutting temperature when using the coolant. The coolant system is therefore needed as a safeguard to a system from overheating and to remove excess heat at the workpiece. It is necessary to get the workpiece required size control and shape. The coolant system has the task of cooling and lubricating machines and cutting tools.

According to a research done by University of Northern Iowa (2003) laboratory tests demonstrated that the heat generated during machining has a definite impact on the wear of the tool. Reducing the temperature of the cutting tool is essential as a tiny decrease in temperature significantly extends the life of the cutting tools.

In general, cutting oils and cutting fluids are the prevalent kinds of coolant used in manufacturing. The interface at the cutting point between the cutting edge of the tool and the chip is avoided using the cutting fluid which is used in the CNC machine coolant system. Friction is prevented at the interface in order to avoid the heat. Courbon et al. (2009) emphasized that the thermos-mechanical interaction was formed for the foregoing advantages by the acted coolant. On the other hand, Mia and Dhar (2015) strongly stated that these advantages are diminished by environmental degradation and human operator poor health state caused by the environmentally incompatible coolant. 80% of the heat generated was carried by chips, while the remaining 20% is transferred to the tool and workpiece. This total of 20% uses coolant to minimise the temperature rise.

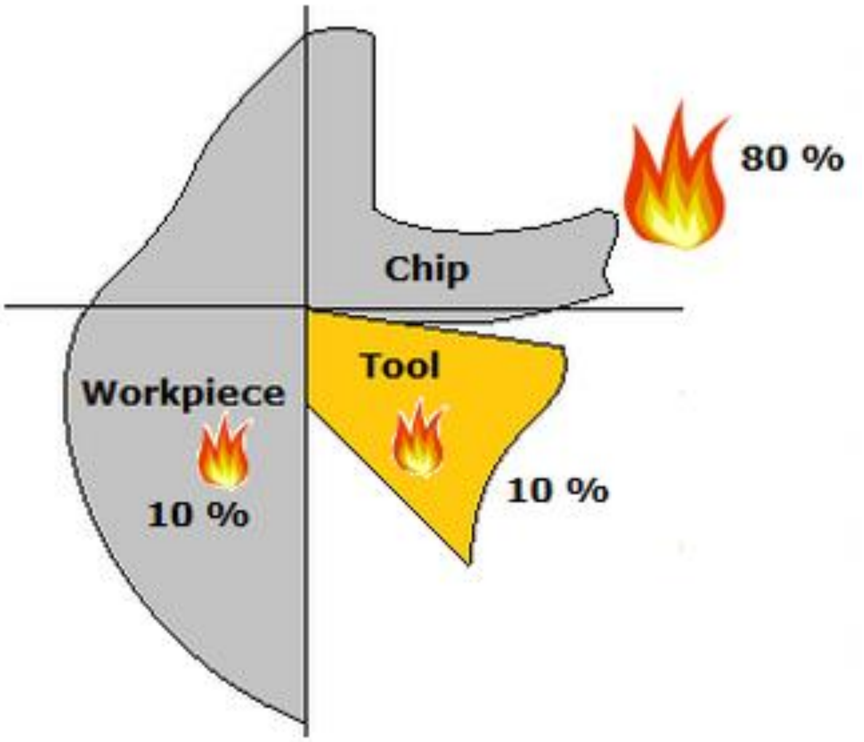

Figure 1.1: The percentage of heat generated (Source: https://www.cadem.com/single-post/cnc-machining-heat-evacuation)

Next, the use of coolant fluids had impacted health, environment and also the economy. The analysis is focusing on the effect of the coolant and temperature on the surface roughness using the minimal quantity lubricant (MQL) compare to the conventional flooded lubricant.

1.1.1 Dry Machining

Dry machining is a metal removal method that does not use coolant. The use of dry machining has many benefits such as being able to completely eliminate the damaging cutting fluid, reducing manufacturing costs on the cutting fluid, achieving high surface finish with high velocity and reducing operating time. As indicated by Groover (2002), in the situation of low cutting speed, the dry machining is capable of extending the tool life. The low cutting speed results in a low rate of manufacturing. Dry machining also creates adverse effects such as tool overheating. According to Sreejith and Ngoi, (2000), the benefit of dry machining include atmospheric and water non-pollution, no residue in the swarf that will be reflected in decreased costs of disposal and cleaning, besides, there is no health hazard and it is skin free and allergy free. On the other hand, it also provides cost savings in machining. Diniz et al. (2010) described that elevated friction happens between the tool and the workpiece can obviously lead to increased temperature and ultimately lead to greater oxidation, abrasion and diffusion. In addition, it is discovered that the excessive heat in the workpiece would impede tight tolerances and metallurgical damage. Therefore, dry machining is not regarded either practical or commercial in such circumstances.

1.1.2 Conventional Flood Lubrication (Wet Cooling)

Samatham et al. (2016) emphasised that conventional wet machining uses up to 12,000 litres of coolant per hour. As eloquently stated by Imran et al. (2014), cutting temperature is not surprisingly a main factor in the wear of the tool and the cutting process. During machining, high temperatures and stresses are produced by the combination of a large primary shear zone heat source and large secondary shear stresses applied in the cutting region. In general, a coolant performs many functions including heat dissipation from the cutting zone, lubrication between tool and workpiece, chip evacuation and removal of unwanted substances from the surface of workpiece. The main role of the coolant is to reduce the heat by reducing the friction in the cutting area. The coolant availability has been discovered to be the most important factor influencing tool performance with greater coolant pressure, increasing the tool life by 740% in nickel alloys machining. The high tool life was ascribed to effectively remove chips, reduce friction, reduction of cutting forces and supply of coolant in the cutting area which result in decreasing the region of seizure. Cooling lubricants also decreased the thrust and torque forces.

1.1.3 Minimal Quantity Lubrication (MQL)

Barczak et al. (2010) stated that due to the acquisition and disposal of liquid, current fluid delivery systems are frequently seen to boost manufacturing costs. In addition, waste fluids have an adverse effect on the environment. One of the effective techniques of fluid decrease used in machining is minimum quantity lubrication (MQL), in which a tiny amount of fluid in the form of aerosol is directed into the machining region. It was also discovered that cooling costs can be as high as 17% of the total price of manufacturing part, while depreciation and waste disposal contribute about 54% of the price of cooling. Therefore, there are possibly significant financial advantages to be obtained from decreasing the use of fluids. According to Fratila (2009), MQL significant benefits are decreasing the fluid consumption, lowering costs, decreasing adverse environmental impact as well as enhancing general machining performance and apparent quality. In addition, several researches have been carried out to demonstrate that MQL delivers better efficiency than dry and wet machining. Li and Lin (2012) studied that MQL can drastically reduce the surface roughness and enhance the lifespan of the tool and the formation of burr. Li and Lin (2012) also discovered that the use of MQL in micro grinding resulted in a substantial reduction in surface roughness and a substantial increase in tool life. Additionally, low lubricant residue is left on the chips, workpiece and tool holder making it simpler and cheaper to clean. Thus, both the environmental threats and the production costs can be reduced by MQL.

Therefore, to study this issue, a few techniques must be acquired. The process of directly introducing minute quantities of high-quality lubricant to the cutting tool or workpiece is called the MQL. Minimal quantity lubrication (MQL) is selected analyse this issue with respect to the surface roughness, tool wear, temperature deviation, cutting depth and the amount of coolant used. This is due to its vast advantages in improving machining efficiency, lowering the cost of removing used oil as well as minimizing machine tool clearing cycle time and energy use. The objective of this project is to program Programmable Logic Controller in CNC turning machine for an automated coolant supply system as well as to analyse the efficiency of the automated coolant system in CNC turning machine in terms of surface roughness. According to a research by Unist (2012), after the introduction of MQL, Ford finds that there are 13% decline to the overall price. Moreover, it was again specified that this cost reduction was due to the improved tool life, a substantial reduction in fluid, decreased coolant handling expenses, decreased maintenance and increased machine uptime. In addition, by reducing the use of fluids and decreasing the need for coolant treatment and disposal, thus MQL minimizes the environmental impact.

Figure 1.2: Coolant system in CNC turning (Source: https://www.sundary.com/whats-different-between-cnc-turning-and-cnc-milling/)

1.2 Problem Statement

A wet cooling method is used during the conventional CNC machine in order to reduce the heat produce and the excess chips that presence at the workpiece. However,